PATENT ABSTRACTS OF JAPAN

(11)Publication number : 08-337853
(43)Date of publication of application : 24.12.1996

(51)Int.Cl. C22C 38/00
C22C 38/40

(21)Application number : 07-142917
(22)Date of filing : 09.06.1995

(71)Applicant : HITACHI LTD
(72)Inventor : ARAI MASAHIKO
AONO YASUHISA
NAKADA KIYOTOMO
KASAHARA SHIGEKI
KATO TAKAHIKO
HIRANO TATSUMI

(54) HIGH CORROSION RESISTANT AND HIGH STRENGTH AUSTENITIC SINTERED STEEL, ITS PRODUCTION AND USE THEREOF

(57)Abstract:
PURPOSE: To produce an austenitic steel excellent in corrosion resistance, strength and radiation irradiation damage resistance by extremely refining the grain size in a uniform manner, to provide a method for producing the same and to produce nuclear reactors, nuclear fusion reactors and their structural parts using the same.
CONSTITUTION: This high corrosion resistant and high strength austenitic sintered steel has a compsn. contg., by weight, ≤0.1% C, ≤1% Si, ≤2.0% Mn, 9 to 30% Ni and 14 to 20% Cr, in which the average grain size is regulated to ≤1μm and having ≥90vol.% austenitic phase. Or, at least one kind among ≤3% Mo, ≤1.0% Ti, ≤2.0% Zr and ≤1.0% Nb is incorporated therein, and these steels are used for parts applied with neutron irradiation and contacted with high temp. water such as structural materials in nuclear reactors and nuclear fusion reactors.

CLAIMS

[Claim(s)]
[Claim 1]High-corrosion-resistance high intensity austenite sintered steel which less than C0.1' less than Si1%, less than Mn2.0%, 9 to 30% of nickel, and 14 to 20% of Cr are contained, and an average crystal grain diameter is 1 micrometer or less, and is characterized by having an austenite phase more than 90 volume % by weight.
[Claim 2]High-corrosion-resistance high intensity austenite sintered steel which less than C0.1' less than Si1%, less than Mn2.0%, 9 to 30% of nickel, 14 to 20% of Cr, and less than Mo3% are contained, and an average crystal grain diameter is 1 micrometer or less, and is characterized b

having an austenite phase more than 90 volume % by weight.
[Claim 3]At weight, they are less than C0.1%, less than Si1%, less than Mn2.0%, 9 to 30% of nickel, 14 to 20% of Cr and less than Ti1.0%, less than Zr2.0%, and Nb1.0%. The following is contained for the following at least one sort or two or more elements 2.0%, High-corrosion-resistance high intensity austenite sintered steel which an average crystal grain diameter is 1 micrometer or less, and is characterized by having an austenite phase more than 90 volume %.
[Claim 4]By weight, the following is contained for at least one sort or two or more elements less than C0.1%, less than Si1%, less than Mn2.0%, 9 to 30% of nickel, 14 to 20% of Cr, less than Mo3% and less than Ti1.0%, less than Zr2.0%, and not more than Nb1.0% 2.0%, High-corrosion-resistance high intensity austenite sintered steel which an average crystal grain diameter is 1 micrometer or less, and is characterized by having an austenite phase more than 90 volume %.
[Claim 5]High-corrosion-resistance high intensity austenite sintered steel comprising:
By weight. They are less than Mo3% and Ti1.0% to steel powder or this which less than C0.1%, less than Si1%, less than Mn2.0%, 9 to 30% of nickel, and 14 to 20% of Cr contain. Hereafter two or more elements of at least one sort or Ti less than Zr2.0% and not more than Nb1.0%, Zr, and Nb. A process of forming the end of machining powder which it is 20 nm or less in crystal grain diameter, and has a processing induction martensitic transformation phase in steel powder containing 2.0% or less.
A process of performing hydrostatic pressure sintering between heat, or extruding between heat for said end of machining powder at temperature of 1000 ** or less.

[Claim 6]weight — less than C0.1%, less than Si1%, less than Mn2.0%, and P — in austenitic steel which contains 9 to 30% of nickel, and 14 to 20% of Cr hereafter S 0.03% 0.045% or less, This steel at temperature of 700 ** - 1050 ** using mechanical processing powder containing a processing induction martensitic phase Solidification heat treatment, Or high-corrosion-resistance high intensity austenite sintered steel, wherein it carries out solidification heat treatment and thermomechanical treatment of this solidified material following it, not less than 90% is an austenite phase in a volume rate of a room temperature and average crystal grain diameters of this phase are 10 nm - 1000 nm.
[Claim 7]weight — less than C0.1%, less than Si1%, less than Mn2.0%, and P — in austenitic stee which contains 9 to 30% of nickel, 14 to 20% of Cr, and 2 to 3% of Mo hereafter S 0.03% 0.045% or less, Mechanical processing powder containing a processing induction martensitic phase is used for this steel, Solidification heat treatment or solidification heat treatment, and thermomechanical treatment of this solidified material following it are carried out at temperature of 700 ** - 1050 **, High-corrosion-resistance high intensity austenite sintered steel, wherein not less than 90% is an austenite phase in a volume rate of a room temperature and average crystal grain diameters of this phase are 10 nm - 1000 nm.
[Claim 8]By weight, less than C0.1%, less than Si1%, less than Mn2.0%, less than P0.045%, less than S0.03%, 9 to 30% of nickel, 14 to 20% of Cr, And in austenitic steel which contains the following 2.0%, at least one sort or two or more elements among less than Ti1.0%, less than Zr2.0%, and less than Nb1.0% this steel, Using mechanical processing powder containing a processing induction martensitic phase, at temperature of 700 ** - 1050 ** Solidification heat treatment, Or high-corrosion-resistance high intensity austenite sintered steel, wherein it carries out solidification heat treatment and thermomechanical treatment of this solidified material following it, not less than 90% is an austenite phase in a volume rate in a room temperature and average crystal grain diameters of this phase are 10 nm - 1000 nm.
[Claim 9]At weight, they are less than C0.1%, less than Si1%, less than Mn2.0%, less than P0.045 and less than S0.03%. 9 to 30% of nickel, 14 to 20% of Cr, 2.0 to 3.0% of Mo, And less than Ti1.0% less than Zr2.0%, and Nb1.0% In austenitic steel included below 2.0%, in following at least one sor or two or more elements this steel, Using mechanical processing powder containing a processin induction martensitic phase, at temperature of 700 ** - 1050 ** Solidification heat treatment, Or high-corrosion-resistance high intensity austenite sintered steel, wherein it carries out solidification heat treatment and thermomechanical treatment of this solidified material followin it, not less than 90% is an austenite phase in a volume rate of a room temperature and average

crystal grain diameters of this phase are 10 nm - 1000 nm.
[Claim 10]By weight. Less than C0.1%, less than Si1%, less than Mn2.0%, 9 to 30% of nickel, and 14 to 20% of Cr to steel powder or this which is contained an element of plurality [at least one sort] of Ti, Zr, and Nb less than Mo3%, less than Ti1.0%, less than Zr2.0%, and not more than Nb1.0%, using attritor or a ball mill for powder mixture which fulfills this presentation by making into atomization powder or the whole steel powder which contains the following 2.0% in total below 100 ** for 30 to 100 hours — mechanical — grinding — or alloying treatment being carried out and, A process of forming the end of machining powder a crystal grain diameter has processing induction martensitic transformation phase of 15 nm or less, Not less than 90% becomes an austenite phase by a volume rate of a room temperature by carrying out the last thermomechanical treatment in the above-mentioned temperature region which follows solidification heat treatment or solidification heat treatment, and it in a temperature requiremen (700 ** - 1050 **) in this end of machining powder at hydrostatic pressure sintering between heat, or an extrusion process between heat, A manufacturing method of high-corrosion-resistance high intensity austenite sintered steel adjusting an average crystal grain diameter in 10 nm - 1000 nm.
[Claim 11]By weight. They are less than Mo3%, less than Ti1.0%, less than Zr2.0%, and Nb1.0% to austenitic steel or this containing less than C0.1%, less than Si1%, less than Mn2.0%, 9 to 30% of nickel, and 14 to 20% of Cr. Two or more following elements of Ti, Zr, and Nb by at least one sort. It consists of austenitic steel which contains the following 2.0% in total, and the proof stress Y (MPa) is within the limits of a value of a room temperature calculated by the following (1) type and (2) types from the average crystal grain diameter d (nm) 0.2%, High-corrosion-resistance high intensity austenitic steel, wherein said mean particle diameter is 1000 nm or les

(1) The formula : Y=-177logd+936 (2) type : Y=-240logd+1233 [Claim 12]By weight. They are les than Mo3%, less than Ti1.0%, less than Zr2.0%, and Nb1.0% to austenitic steel or this containing less than C0.1%, less than Si1%, less than Mn2.0%, 9 to 30% of nickel, and 14 to 20% of Cr. Two c more following elements of Ti, Zr, and Nb by at least one sort. It consists of austenitic steel which contains the following 2.0% in total, and the proof stress Y (MPa) is within the limits of a value of a room temperature calculated by the following (3) types and (4) types from pace-of-expansion [of said steel] delta (%) 0.2%, High-corrosion-resistance high intensity austenitic steel, wherein an average crystal grain diameter of said steel is 1000 nm or less.
(3) The formula : Y=-290logdelta+720 (4) type : Y=-670logdelta+1375 [Claim 13]By weight. The are less than Mo3%, less than Ti1.0%, less than Zr2.0%, and Nb1.0% to austenite sintered steel o this containing less than C0.1%, less than Si1%, less than Mn2.0%, 9 to 30% of nickel, and 14 to 20% of Cr. Two or more following elements of Ti, Zr, and Nb by at least one sort. A nuclear reactor inner material consisting of austenite sintered steel which contains the following 2.0% i total.
[Claim 14]By weight. They are less than Mo3%, less than Ti1.0%, less than Zr2.0%, and Nb1.0% t austenite sintered steel or this containing less than C0.1%, less than Si1%, less than Mn2.0%, 9 30% of nickel, and 14 to 20% of Cr. Two or more following elements of Ti, Zr, and Nb by at least one sort. A fastening member consisting of austenite sintered steel which contains the followin 2.0% in total.
[Claim 15]High-corrosion-resistance high strength structural members to which this member i characterized by an average crystal grain diameter being 1 micrometer or less in a structural member which consists of austenitic steel which contacts water and receives neutron irradiati

[Claim 16]In a nuclear reactor provided with a neutron source pipe, a core support plate, a neutron instrumentation tube, a control rod inserted pipe, a shroud, a top guide, a covering pip for fuel assemblies, and a structural part of a channel box in a reactor pressure vessel, A nucl reactor, wherein at least one of said the structural parts consists of austenitic steel which has an average crystal grain diameter of 1 micrometer or less.
[Claim 17]In a nuclear reactor provided with a neutron source pipe, a core support plate, a neutron instrumentation tube, a control rod inserted pipe, a shroud, a top guide, a covering pip

for fuel assemblies, and a structural part of a channel box, at least one of said the structural parts by weight. Less than C0.1%, less than Si1%, and Mn2.0% 9 to 30% of nickel and 14 to 20% of Cr are included hereafter, Or a nuclear reactor becoming this by at least one sort from austenitic steel which has an average crystal grain diameter of 1 micrometer or less including the following 2.0% in total about two or more elements of Ti, Zr, and Nb less than Mo3%, less than Ti1.0%, less than Zr2.0%, and not more than Nb1.0%.

[Claim 18]In a nuclear power plant which turns a steam turbine by a thermal output acquired with nuclear fuel stored in a reactor pressure vessel, drives a dynamo by rotation of this steam turbine, and obtains electric generating power by it, Thermal outputs of said nuclear reactor are not less than 3200 MW and reactor pressure 7.0MPa. The degree of nuclear reactor water temperature of not less than 288 ** and said electric generating power are not less than 1100 MW above, A nuclear power plant could use at least one of each of the component parts of a neutron source pipe formed in said reactor pressure vessel, a core support plate, a neutron instrumentation tube, a control rod inserted pipe, a shroud, and a top guide by no exchanging for 30 years or more, and making an operating ratio into not less than 85%.

[Claim 19]In a nuclear power plant which turns a steam turbine by a thermal output acquired with nuclear fuel stored in a reactor pressure vessel, drives a dynamo by rotation of this steam turbine, and obtains electric generating power by it, A thermal output of said nuclear reactor is not less than 4300 MW, and reactor pressure is 7.0MPa. A nuclear power plant characterized by the degree of nuclear reactor water temperature having considered it as not less than 288 **, and said electric generating power making constant ****** after not less than 1500 MW, not less than 85% of an operating ratio, and 12-month operation less than 50 days per time above.

[Claim 20]In component parts for nuclear reactors provided with a neutron source pipe, a core support plate, a neutron instrumentation tube, a control rod inserted pipe, a shroud, a top guide, a covering pipe for fuel assemblies, and a structural part of a channel box in a reactor pressure vessel, Component parts for nuclear reactors, wherein at least one of said the structural parts has all the austenite textures and an average crystal grain diameter consists of austenitic steel which is 1 micrometer or less.

[Claim 21]In a diverter which a ceramic style is provided at the plasma side in a vacuum housing which has water cooled structure, and has water cooled structure, and a nuclear fusion reactor provided with component parts of a first wall which a ceramic style is provided in the plasma sid and has water cooled structure, A nuclear fusion reactor with which at least one of said the component parts is characterized by an average crystal grain diameter consisting of austenitic steel which is 1 micrometer or less.

[Claim 22]In component parts for nuclear fusion reactors provided with a vacuum housing which has water cooled structure, a diverter which a ceramic style is provided and has water cooled structure, and a first wall which a ceramic style is provided in the plasma side and has water cooled structure, Component parts for nuclear fusion reactors in which at least one of said the component parts is characterized by an average crystal grain diameter consisting of austenitic steel which is 1 micrometer or less.

[Translation done.]

DETAILED DESCRIPTION

[Detailed Description of the Invention]
[0001]
[Industrial Application]This invention relates to suitable structural steel worker austenitic steel to use it under corrosive environment and high stress load environment, its manufacturing method, and a use with respect to new austenitic steel. This invention relates to suitable structural steel worker austenitic steel to use it under radiation irradiation environment, such as a reactor core, especially, its manufacturing method, and a use with respect to new austenitic steel.
[0002]
[Description of the Prior Art]Austenitic stainless steel possesses the characteristic suitable as structural material from the field of corrosion resistance, processability, and economical efficiency.
It is widely used as a material of a structural part.
However, as compared with other structural steel, it has a fault which is not enough. Without changing the alloy composition of the above-mentioned austenitic steel, the anticorrosion characteristic is maintained and there is what is called a crystal grain diameter minuteness making method that introduces many grain boundaries used as deformation resistance into material as a method of raising intensity. The grain boundary is a boundary between single crystals with different crystal orientation, and has the crystal structure which was different fron the crystalline lattice of the orderly atomic arrangement within a grain, and was confused. Although the rearrangement which bears modification exercises the inside of a grain under stres and modification is caused, existence of a grain boundary causes an interaction with a rearrangement, and when a rearrangement passes through the above-mentioned disordered grai boundary, it induces strong resistance. This deformation resistance increases in proportion to - 1-/square of a crystal grain diameter as a function of a crystal grain diameter, and following the so-called principle of hole PETCHI is known well.
[0003]A processing induction martensitic transformation and the reverse transformation in an elevated temperature are made to cause to austenitic steel in recent years by a rolling process The research to which minuteness making of the austenite crystal grain diameter was carried o to submicron size is progressing. The manufacturing method etc. are reported to 400 - 402 pages as an example in 529 - 535 pages and the Japan Institute of Metals report, the 27th volume, No. 5, and 1988 in iron, steel, the Iron and Steel Institute of Japan, the 80th volume, an 1994.
[0004]Austenitic steel contains corrosion-resistant Cr and is mostly used from having the resistance to the bottom of corrosive environment as an object for manufacture of the structural part used, for example within a nuclear reactor. However, it is known by the long-ter radiation irradiation which wears the austenitic steel member of a light water reactor core while in use that mechanical properties, such as a segregation to the grain boundary of an impurity o a ductile fall, will deteriorate. For example, in the austenitic stainless steel which used the crys grain diameter as about tens of micrometers polycrystal by the usual solution heat treatment, when the neutron irradiation more than $4 \times 10^{25} n/m^2$ is received with a dose in a reactor core region, uniform stretch will be 1% or less. base, such as a hole, an interstitial atom, etc. in whicl the metal study mechanism of the strength deterioration phenomenon under such an exposure introduced by exposure, — it is explained that deformation resistance increases by existence c the secondary defect in which defects gather and are formed.
[0005]
[Problem(s) to be Solved by the Invention]However, in the above-mentioned manufacturing method, in the reverse transformation heat treatment process or thermoforming process whicl is a process at which solution-ized material is rolled at a stretch as a general tendency, it depends to the workability of the influence of strong processability, i.e., a rolling direction, and thickness direction strongly, and a crystal grain diameter becomes uneven easily to the above-

mentioned direction. By this method, workability has a maximum and fine-crystal[super-]-izing from a submicron to a nano-scale is more difficult.
[0006]The austenitic stainless steel which has a nano crystal is added to the corrosion resistance which a presentation has, and high intensity is attained for the super-minuteness making of a crystal grain, and although it is a super-fine crystal therefore, it has an advantage which resistance has also in the dilution effect of the impurity in a grain boundary, and the organization change especially by radiation damage.
[0007]There are the following technical problems in manufacture of the nano crystallization bulk material which has an austenitic steel presentation. The process of carrying out strong processing of the austenite phase more is required for nano-scale-izing of a crystal grain diameter at low temperature. Methods other than strong rolling of the solution-ized member with which a strong rolling organization remains need to be chosen for equalization of a crystal grain diameter. Manufacturing methods expectable to the above technical problem include practical use of the mechanical grinding method. In this process, it metamorphoses into a processing induction martensitic phase more detailed than the rolling method, therefore big and rough-ization is controlled also in solidification heat treatment in the end of machining powder, and nano crystallization of the raw material complications is easy to be carried out. By this method, it is expected also in the thermomechanical treatment in the elevated temperature for the organization adjustment following solidification heat treatment in the end of machining powder, and it that the heterogeneity of a crystal grain diameter will be sufficiently small compared with a rolling process.
[0008]The purpose of this invention is by carrying out super-minuteness making of the crystal grain diameter uniformly to provide corrosion resistance, intensity, austenitic steel excellent in radiation irradiation-proof damage, its manufacturing method, the nuclear reactor using it and nuclear fusion reactors, and those component parts.
[0009]
[Means for Solving the Problem]It is weight, and this invention contains less than C0.1%, less than Si1%, less than Mn2.0%, 9 to 30% of nickel, and 14 to 20% of Cr, and an average crystal grain diameter is 1 micrometer or less, and it is in high-corrosion-resistance high intensity austenite sintered steel having an austenite phase more than 90 volume %.
[0010]This inventions are less than Mo3%, less than Ti1.0%, less than Zr2.0%, and Nb1.0% to an above-mentioned alloy. The following is included for the following at least one sort or two or more elements 2.0% in a total amount of Ti, Zr, and Nb.
[0011]This invention is weight, Less than C0.1%, less than Si1%, less than Mn2.0%, 9 to 30% of nickel, and 14 to 20% of Cr to steel powder or this which is contained two or more elements of a least one sort or Ti less than Mo3%, less than Ti1.0%, less than Zr2.0%, and not more than Nb1.0% Zr, and Nb. To steel powder which contains the following 2.0%, with a crystal grain diameter of 2(nm or less And a process of forming the end of machining powder it has a processing induction martensitic transformation phase, It is in high-corrosion-resistance high intensity austenite sintered steel having the process of performing hydrostatic pressure sintering between heat, or extruding between heat for said end of machining powder at temperature of 1000 ** or less.
[0012]This invention is weight and are less than C0.1%, less than Si1%, less than Mn2.0%, and P0.045%. Following and S0.03% In austenitic steel which contains 9 to 30% of nickel, and 14 to 20% of Cr hereafter, This steel at temperature of 700 ** - 1050 ** using mechanical processing powder containing a processing induction martensitic phase Solidification heat treatment, Or solidification heat treatment and thermomechanical treatment of this solidified material following it are carried out, and not less than 90% is an austenite phase in a volume rate of a room temperature, and it is in high-corrosion-resistance high intensity austenite sintered steel, wherein average crystal grain diameters of this phase are 10 nm - 1000 nm.
[0013]This invention contains Mo, Ti, Zr, and Nb like the above-mentioned.
[0014]This invention is weight, They are less than Mo3%, less than Ti1.0%, less than Zr2.0%, and Nb1.0% to steel powder or this containing less than C0.1%, less than Si1%, less than Mn2.0%, 9 tc 30% of nickel, and 14 to 20% of Cr. Two or more following elements of Ti, Zr, and Nb by at least one sort. using attritor or a ball mill for powder mixture which fulfills this presentation by making

into atomization powder or the whole steel powder which contains the following 2.0% in total below 100 ** for 30 to 100 hours — mechanical — grinding — or alloying treatment being carried out and, A process of forming the end of machining powder it has a processing induction martensitic transformation phase with a crystal grain diameter of 15 nm or less, Not less than 90% becomes an austenite phase by a volume rate of a room temperature by carrying out the last thermomechanical treatment in the above-mentioned temperature region which follows solidification heat treatment or solidification heat treatment, and it in a temperature requirement (700 ** - 1050 **) in this end of machining powder at hydrostatic pressure sintering between heat, or an extrusion process between heat, It is in a manufacturing method of high-corrosion-resistance high intensity austenite sintered steel adjusting an average crystal grain diameter in 10 nm - 1000 nm.

[0015]This invention is weight, They are less than Mo3%, less than Ti1.0%, less than Zr2.0%, and Nb1.0% to austenitic steel or this containing less than C0.1%, less than Si1%, less than Mn2.0%, 9 to 30% of nickel, and 14 to 20% of Cr. Two or more following elements of Ti, Zr, and Nb by at least one sort. It consists of austenitic steel which contains the following 2.0% in total, and the 0.2% proof stress Y of a room temperature (MPa) is within the limits of a value calculated by the following (1) type and (2) types from the average crystal grain diameter d (nm), It is in high-corrosion-resistance high intensity austenitic steel, wherein said mean particle diameter is 1000 nm or less.

[0016](1) formula: — Y=-177logd+936 (2) type: — Y=-240logd+1233 — further, This invention consists of austenitic steel which has an above-mentioned presentation, and the 0.2% proof stress Y of a room temperature (MPa) is within the limits of a value calculated by the following (3) types and (4) types from pace-of-expansion [of said steel] delta (%), It is in high-corrosion-resistance high intensity austenitic steel, wherein an average crystal grain diameter of said stee is 1000 nm or less.

[0017]The formula : Y=-290logdelta+720 (4) type : (3) Y=-670logdelta+1375 this invention, By weight. They are less than Mo3%, less than Ti1.0%, less than Zr2.0%, and Nb1.0% to austenite sintered steel or this containing less than C0.1%, less than Si1%, less than Mn2.0%, 9 to 30% of nickel, and 14 to 20% of Cr. Two or more following elements of Ti, Zr, and Nb by at least one sort. It is in a nuclear reactor inner material consisting of austenite sintered steel which contain the following 2.0%, and is constituted in total by austenitic steel other-mentioned above.

[0018]This invention is weight, They are less than Mo3%, less than Ti1.0%, less than Zr2.0%, and Nb1.0% to austenite sintered steel or this containing less than C0.1%, less than Si1%, less than Mn2.0%, 9 to 30% of nickel, and 14 to 20% of Cr. Two or more following elements of Ti, Zr, and Nl by at least one sort. It is in a fastening member consisting of austenite sintered steel which contains the following 2.0% in total, and is constituted by austenitic steel of the other above-mentioned.

[0019]This invention contacts water and this member is in high-corrosion-resistance high strength structural members, wherein an average crystal grain diameter is 1 micrometer or less in a structural member which consists of austenitic steel which receives neutron irradiation.

[0020]In a nuclear reactor at which this invention was provided with each structural part of a neutron source pipe, a core support plate, a neutron instrumentation tube, a control rod inserte pipe, a shroud, a top guide, a covering pipe for fuel assemblies, and a channel box in a reactor pressure vessel, It is in a nuclear reactor constituting the surface which receives austenitic ste or neutron irradiation concerning above-mentioned this invention for at least one of said structural part of this nuclear reactor, and touches high temperature high pressure water with steel of above-mentioned this invention, and component parts in the nuclear reactor.

[0021]In component parts for nuclear reactors in which this invention was provided with each structural part of a neutron source pipe, a core support plate, a neutron instrumentation tube, control rod inserted pipe, a shroud, a top guide, a covering pipe for fuel assemblies, and a channel box in a reactor pressure vessel, At least one of said the component parts is constituted by the above-mentioned austenitic steel which has all the austenite textures.

[0022]In a nuclear power plant which this invention turns a steam turbine by a thermal output acquired with nuclear fuel stored in a reactor pressure vessel, drives a dynamo by rotation of

this steam turbine, and obtains electric generating power by it, Thermal outputs of said nuclear reactor are not less than 3200 MW and reactor pressure 7.0MPa. Nuclear reactor temperature of not less than 288 ** and said electric generating power are not less than 1100 MW above, At least one of each of the component parts of a neutron source pipe formed in said reactor pressure vessel, a core support plate, a neutron instrumentation detection tube, a control rod inserted pipe, a shroud, and a top guide can be used by no exchanging for 30 years or more, and it is in a nuclear power plant making an operating ratio into not less than 85%.

[0023]In a nuclear power plant which this invention turns a steam turbine by a thermal output acquired with nuclear fuel stored in a reactor pressure vessel, drives a dynamo by rotation of this steam turbine, and obtains electric generating power by it, A thermal output of said nuclear reactor is not less than 4300 MW, and reactor pressure is 7.2MPa. It is in a nuclear power plant, wherein nuclear reactor temperature considered it as not less than 288 ** and said electric generating power makes constant ****** after not less than 85% and 12-month operation less than 50 days for an operating ratio of not less than 1500 MW per time above.

[0024]Combination with the above-mentioned austenitic steel of a nuclear reactor and a nuclear power plant in this invention is natural. It is indispensable to raise a steam condition to efficient-ization of nuclear power generation, a steam obtained at a nuclear reactor for that purpose is made into a combined cycle with a gas turbine, and it is attained by obtaining overheated steam made into a steam (300 ** - 500 **) using the exhaust heat.

[0025]In a nuclear fusion reactor provided with a first wall which, as for this invention, a ceramic style is provided in the diverter [which a ceramic style is provided at the plasma side in a vacuum housing which has water cooled structure, and has water cooled structure], and plasma side, and has water cooled structure, A vacuum housing of said component parts of this nuclear fusion reactor which has at least one water cooled structure further, a diverter which a ceramic style is provided and has water cooled structure, And a thing for which austenitic steel concerning above-mentioned this invention constituted at least one of the first walls which has the water cooled structure by which a ceramic style was provided in the plasma side, Or it is in a nuclear fusion reactor constituting the surface which receives neutron irradiation and touches high temperature high pressure water with steel of above-mentioned this invention, or component parts in a nuclear fusion reactor.

[0026]Proof stress of the above in a room temperature is [300 or more MPa and 0.5% of pace o expansion] preferred, and steel of this invention has the proof stress 400 - 600MPa, and 10 to 30% of an especially preferred pace of expansion.

[0027]It can be used for 30 years or more, without exchanging a structure in a nuclear reactor by using steel concerning this invention for the above-mentioned structure in a BWR nuclear reactor, and can be especially used like 40 years. In use over a long period of time to large scale which is not less than 3200 MW of thermal outputs, reactor pressure of 7.0 or more MPa, and the temperature of not less than 288 ** as a nuclear reactor, it is effective.

[0028]In an ABWR nuclear reactor using steel concerning this invention similarly, they are not less than 4300 MW of thermal outputs, and furnace pressure power 7.2MPa. Above, it is considered as temperature of not less than 288 **, and large scale-ization of not less than 150(MW can attain electric generating power. Also in this ABWR, it becomes usable [30 years or more] by no exchanging about the above-mentioned structural material.

[0029]It is possible to make the amount of exposures into below 20mSv / man-year, and to make constant ****** into the extraction burnup 45 - 70 GWd/t less than 30 days not less tha 90% of an operating ratio, not less than 35% of thermal efficiency, and void coefficient-2.8—4.2% at the time of constant **, by using steel especially applied to this invention.

[0030]

[Function]High intensity-ization of austenitic steel excellent in the corrosion resistance which this invention tends to solve is solvable by the super-minuteness making of a crystal grain diameter. Since the grain boundary becomes an obstacle of the sliding motion of the rearrangement which bears plastic deformation, this is explained by the ability of-izing of the plastic deformation resistance to be carried out [****] by raising the density of a grain boundary to a limit.

[0031]As for the super-minuteness making of the austenitic steel crystal grain to a nano-scale, t is more efficient to apply the character of the processing induction martensitic transformation of the austenitic stainless steel by processing and the reverse transformation to the austenite phase in an elevated temperature. Conventionally, by the method of rolling the processing method, workability has a maximum and detailed processing induction martensite is not accumulated enough. It is good to apply a metallurgical method to super-minuteness making in the end of a grain, to be able to attain strong processing extremely, and to utilize the mechanical grinding which can use an alloying process together. The attritor or the planet type ball mill which the mass production in the end of machining powder can expect fits the strong processing of the powdered material. an initial crystal structure makes the powder which is an austenite phase (gamma) of face centered cubic structure metamorphose into the martensitic phase (alpha') of body-centered cubic structure by processing — it is good for particle diameter to carry out with at least 15 nm or less alpha' overly for obtaining detailed gamma-phase of at least several 10-nm particle diameter at a reverse transformation.

[0032]HIP which a large-sized member tends to obtain with actual condition art, or the extrusion process between heat is preferred for the solidification in the above-mentioned end of machining powder. It is better for more than the temperature more than region, i.e., 700 **, that can sinter the end of machining powder to have been desirable, and to attach conditions with a recrystallizing temperature of 900 ** or less, when asking especially for nano-scale particle diameter although it depends for solidification temperature on the last crystal grain diameter demanded. Above recrystallizing temperature, atomic diffusion is more active and growth of particle diameter produces it. When obtaining the crystal grain diameter of submicron size, processing at not less than 900 ** is also possible. Atomic diffusion is more active also at low temperature at work of a lot of lattice defects (point defect) introduced by processing in the end of machining powder. When an unsintered portion exists in solidifying material by solidification heat treatment at the temperature near [this / above-mentioned] the minimum, it is possible tc extinguish them by hot working more than the subsequent above-mentioned lower limit temperature. Anyway, in order to make it the last crystal grain diameter demanded with adjustment and a homogeneous organization, it is desirable to carry out hot working, such as rolling, in 700 more ** - 1050 **. When manufacturing the member of various shape, such as a stick, a board, a belt, and pipe shape, it is desirable to process it at the above-mentioned last particle-diameter-control process.

[0033]About this austenitic steel, depending on the conditions with which the demand of corrosion resistance, intensity, exposure-proof nature, etc. is filled, the mean particle diameter of a desirable crystal is being in the range of 10 to 1000 nm, and the crystal grain diameter demanded especially by the deformation behavior of fine crystal austenitic steel is classified intc three fields. The crystal grain diameter to the nano-scale in metal and an alloy and the relation of proof stress have the particle diameter A corresponding to the peak point of proof stress, as shown in drawing 1 as a general tendency. The field where proof stress decreases with reductior in particle diameter, and modification by rearrangement cannot break out easily (elongation is small). Namely, proof stress increases according to the field I to A which shows the maximum yield strength value from 10 nm, and the above-mentioned hole PETCHI rule. It is divided into the particle diameter field II which modification advances by the sliding motion of a rearrangement within a crystal grain, and has plastic elongation comparatively, i.e., the field from A to 500 nm, and the field III from 500 nm to 1000 nm. Even if the minuteness making of above-mentioned alpha' for obtaining the last gamma-phase particle diameter estimates setting out of 10 nm of minimums of the field I to be the maximum, it is because it remains in the range of 5 tc 10 nm. It is because 1000 nm of a maximum is considered to be a minimum of the present super-minuteness making technology trends. This field has the super-elasticity effect by grain boundary way Li in an elevated temperature, and it has an advantage which raises the processability in an elevated temperature. The field II is the most suitable field in intensity, and the demand of operating intensity is suitable for the member desired most. The field III is suitab for the member which expects toughness.

[0034]The corrosion resistance of austenitic steel of the above-mentioned range can attain a

crystal uniformity and by carrying out minuteness making more besides the reason for having corrosion-resistant chemical composition. Mechanical grinding can be considered as an organization with few the manufactures in the machining powder end of a non equilibrium solid solution, the segregations of the solute atom within the grain which participates in corrosion by solidification at low temperature, and deposits as compared with the steel manufactured by melting coagulation. This is because it does not pass through a melting process. A corrosive impurity is held with an atom level by the grain boundary which the a large number lattice spacing extended by the minuteness making of the crystal grain, and cannot deposit more easily. Furthermore, the minuteness making of particle diameter affects the formation and the number of pitting, and raises corrosion resistance.

[0035]About the material damage by neutron irradiation, accumulation of the exposure defect which checks the segregation accompanying the exposure induction diffusion generated with austenitic stainless steel with a usual particle diameter of about several 10 nm and plastic deformation is improved by micrifying a crystal grain diameter infinite. The minuteness making of a crystal grain can raise the share of the grain boundary which the lattice spacing extended by the bulk volume rate, and can control segregation generating. The above-mentioned amount of defects which checks the plastic deformation within a grain can be reduced because the interaction of a defect and a grain boundary becomes large and the disappearance frequency of the defect in a grain boundary increases because particle diameter becomes near with the size of an exposure defect.

[0036]As mentioned above, by carrying out minuteness making of the crystal grain diameter of material, and introducing much grain boundaries, intensity raises increase and anticorrosion, and stress-corrosion-cracking-proof nature, and radiation irradiation-proof damage nature improves further. This invention prevents a crack and is to provide the austenitic steel which raised corrosion resistance and radiation damage-proof nature while it raises intensity.

[0037]It is made to contain not less than 9%, although nickel makes an austenite phase stability and improves corrosion resistance. Although the amount of high nickel raises corrosion resistance, since electrochemical reaction is produced in a contact portion and it promotes the corrosion of other members in using it under the same corrosive environment as other members, 30% of a maximum is desirable.

[0038]Not less than 14% of Cr is required in order to raise corrosion resistance. However, when 20% is exceeded, in order to destabilize an austenite phase, and to make a sigma phase generate and to make it embrittle, 14 to 20% is preferred.

[0039]Si and Mn are added as a deoxidizer in the case of manufacture of raw material powder steel, and Mn is further added as a desulfurization agent. According to the JIS of commercial SUS304 and SUS316 grade, 2% or less of Mn is [Si] desirable 1% or less. Especially 0.5 to 1.5% of 0.2 to 0.5% and Mn are [Si] desirable.

[0040]P and S are contained at the time of manufacture of raw material powder, and have a bad effect in corrosion resistance. According to the JIS of commercial SUS304 and SUS316 grade, 0.03% or less of S is [P] desirable 0.045% or less.

[0041]Mo is corrosion resistance and a solid-solution-strengthening type alloying element. However, since s phase will be made to generate and embrittlement of material will be caused if it adds exceeding 3%, for giving good corrosion resistance and intensity, 3% or less and 2 to 3% of addition is preferred.

[0042]When material is used as a welded joint, as for C, it is preferred to make it decrease as much as possible from the corrosion resistance of a heat affected zone, and it is dependent on the amount of C in the raw material powder which can be used. However, it is better to add to strengthening of material, and strengthening of a grain boundary at slight height, when using as a non-welding member. 0.1% is preferred in a maximum. In more than this, a deposit of carbide takes place easily and the characteristic of original austenitic steel is lost.

[0043]Ti, Zr, and Nb are carbide and an oxide formation element.
Since it is an oversize atom in the state of dissolution, the atomic vacancy introduced by exposure by addition of them is adhered, and exposure-proof nature is raised.
0.1%, in the above high carbon presentation, in order that addition of these elements may

generate a lot of carbide containing those elements and may make material weak, it is not effective. Generally, in order for raw material powder to contain nearby oxygen 0.2%, and to also take the amount of content C into consideration and to fix O and C, a maximum of 1.5% of addition of Ti, Zr, and Nb is suitable at 1.0, 2.0, 1.0%, and compound addition respectively in independent addition. The amount of surplus of an alloying element dissolves, and it demonstrates the above-mentioned effect.

[0044]As mentioned above, by carrying out minuteness making of the crystal grain diameter of material, and introducing much grain boundaries, intensity raises increase and anticorrosion, and stress-corrosion-cracking-proof nature, and radiation irradiation-proof damage nature improves further.

[0045]Steel of this invention may be applied to the reinforcement member used by environment-zation from which a grain boundary can generally serve as the main factor of material degradation. It is used in not only a reactor core but water cooling environment, or the environment where hydrogen exists, and may be applied to the structural member which receives radiation irradiation damage.

[0046]

[Example]

The example of the manufacturing method of crystal grain super-minuteness making austenitic steel concerning example 1 this invention is described. In this example, the attritor of drawing 2 was used for mechanical alloying treatment. The composition of this device, It consists of the gas seal 4 which carries out the seal of the substitution gas of the inflow of cooling water 2 of the pulverizing tank 1 made from stainless steel with a capacity of 25 l., and the tank 1, the outflow of cooling water 3, argon, or nitrogen gas, the powder mixture 5 with a weight of 5 kg, the steel balls 6 with a diameter [in a pulverizing tank] of 10 mm, and the agitator arm 7. Rotation is told to the arm shaft 8 from an external drive system, and the agitator arm 7 rotates. The after alloy powder which the ball 6 is agitated, a collision arises between the walls of between the balls 6, the ball 6, and the tank 1, and strong processing of the powder mixture 5 is carried out by the agitator arm 7, and has a fine crystal grain by it was obtained. Revolving speed of the arm shaft 8 was performed at 170 rpm. The main chemical entities (% of the weight) of various crystal grain super-minuteness making austenitic steel concerning this invention are shown in No.1in Table 1-8. The relation between the diffraction peak measured with milling time and an X-ray diffraction method, an average crystal grain diameter, and a phase change was shown in drawing 3, drawing 4, and drawing 5 about the steel type of No.5 of this invention as an example of representation, respectively. The average crystal grain diameter was measured [nm / not less than 100] using the electron microscope using the X-ray diffraction method about 100 nm or less. In an average crystal grain diameter, milling time is isostatic pressing processing (HIP) between heat about this powder that was saturated with about 8 nm in 30 hours or more, and the gamma->alpha ' transformation had completed, and was milled for 60 hours. [1:850 ** of condition x 0.5 hour, 2000 kgf/cm^2] It was alike and was considered more as the bulk material. HIP treatment conditions were summarized in Table 2.

[0047]

[Table 1]

化学組成（wt%）

No.	Fe	Cr	Ni	Mn	P	Si	S	C	Mo		Ti	Zr	Nb	
1	bal.	18.7	9.3	1.7	0.04	0.3	0.02	0.05	—	—	—	—	—	—
2	bal.	19.1	10.1	1.5	0.03	0.4	0.02	0.02	—	—	—	—	—	—
3	bal.	14.8	25.1	1.8	0.03	0.3	0.02	0.08	—	—	—	—	—	—
4	bal.	17.1	18.2	0.5	0.03	0.3	0.02	0.01	—	—	—	—	—	—
5	bal.	17.8	11.8	1.4	0.03	0.3	0.02	0.02	2.1	—	—	—	—	—
6	bal.	16.9	26.6	1.9	0.03	0.4	0.02	0.05	2.5	—	—	—	—	—
7	bal.	14.6	12.5	1.6	0.03	0.3	0.02	0.09	2.3	—	—	—	—	—
8	bal.	19.6	9.2	0.5	0.03	0.3	0.02	0.01	2.8	—	—	—	—	—
9	bal.	18.5	8.5	1.5	0.03	0.2	0.02	0.05	—	—	0.3	—	—	—
10	bal.	18.5	11.1	0.9	0.03	0.2	0.02	0.02	—	—	—	0.3	—	—
11	bal.	18.0	9.5	1.5	0.03	0.3	0.02	0.05	—	—	—	—	0.3	—
12	bal.	18.5	10.8	1.4	0.04	0.2	0.02	0.02	—	—	1.0	—	—	—
13	bal.	19.2	10.2	0.5	0.03	0.2	0.02	0.04	—	—	—	2.0	—	—
14	bal.	18.8	10.2	1.2	0.03	0.5	0.02	0.05	—	—	0.2	0.1	—	—
15	bal.	18.1	12.2	0.8	0.03	0.2	0.02	0.05	—	—	0.7	—	0.2	—
16	bal.	19.1	11.2	0.9	0.03	0.2	0.02	0.05	—	—	—	—	1.0	—
17	bal.	17.2	13.2	1.6	0.03	0.2	0.02	0.02	2.2	—	0.3	—	—	—
18	bal.	17.6	11.1	0.9	0.04	0.6	0.01	0.06	2.1	—	0.2	0.3	—	—
19	bal.	16.3	13.3	1.5	0.03	0.3	0.02	0.05	2.2	—	0.7	—	0.6	—
20	bal.	16.5	12.1	1.4	0.03	0.2	0.01	0.05	2.5	—	—	1.2	—	—
21	bal.	17.4	10.3	0.5	0.03	0.2	0.02	0.04	2.3	—	0.4	—	0.3	—
22	bal.	17.2	11.2	1.2	0.03	0.7	0.02	0.05	2.0	—	—	0.1	0.3	—
23	bal.	16.2	12.3	0.8	0.04	0.2	0.02	0.05	2.5	—	0.2	0.2	0.6	—
24	bal.	17.5	12.0	0.8	0.03	0.2	0.02	0.05	2.1	—	0.5	0.7	0.2	—

表1

[0048]
[Table 2]

表 2

	温度(℃)×時間(h)	圧力(kgf/cm²)
条件1	850(℃)×0.5(h)	2000(kgf/cm²)
条件2	900(℃)×0.5(h)	2000(kgf/cm²)
条件3	950(℃)×0.5(h)	2000(kgf/cm²)

[0049]The example of the manufacturing method of crystal grain super-minuteness making austenitic steel concerning example 2 this invention is described. In this example, the planet type ball mill device of drawing 6 was used for mechanical alloying treatment. The composition of this device consists of the steel balls 15 with a diameter [in a lid / possessing the vacuum suction valve 9, the replacement valve 10 of Ar gas or nitrogen gas, and the small hole 11 for thermometry / made from stainless steel / 12 /, a stainless steel container / 13 / of with a capacity of 500 cc, the powder mixture 14 with a weight of 300 g, and the container 13] of 10 mm. Rotation is told to the turntable 16 from an external drive system, a centrifugal force arises in four sets of the containers 13 crosswise arranged on it, and rotation of an each itself [container 13] also takes place. The ball 15 was rotated in accordance with the wall of the container 13, the collision arose between the walls of between the balls 15, the ball 15, and the container 13, and the after alloy powder which strong processing of the powder mixture 14 is carried out, and has a fine crystal grain was obtained. Revolving speed of the turntable was performed at 150 rpm. The main chemical entities of various crystal grain super-minuteness making austenitic steel concerning this invention are shown in No.1in Table 1-24. It is isostatic pressing processing (HIP) between heat about the after alloy powder which has a fine crystal grain. [1:850 ** of condition x 0.5 hour, 2000 kgf/cm^2] It was alike and was considered more as the bulk material.

[0050]Vacuum annealing of the bulk material in which crystal grain super-minuteness making austenitic steel of the presentation shown in the example 3 table 1 carried out HIP treatment was carried out at the temperature of 900 **, 950 **, 1000 **, and 1050 ** for 0.5 hour, respectively. 1050 ** — 0.25, 0.5, 1.0, and 2.0 — vacuum annealing was carried out for 5. 0 or 10.0 hours, and the tensile test (rate of strain: -10^{-4}/s) was done on these samples at the roor

temperature. In the steel which added steel and Ti with high C concentration, Zr, and Nb, as compared with the steel which does not add steel and Ti with low C concentration, Zr, and Nb, grain growth was overdue, and there was grain growth depressor effect in C, Ti, Zr, and Nb. As an example of representation, to drawing 7 about the steel type of No.5 of this invention The annealing temperature and the average crystal grain diameter of a case for annealing time 30 minutes, The average crystal grain diameter and the relation of proof stress were shown in drawing 8 with practical use 316L steel of the conventional material at the annealing time in the case of 1050 ** annealing temperature, an average crystal grain diameter, and drawing 9, respectively, and the relation between an average crystal grain diameter, proof stress, and elongation was shown in Table 3. It is 0.5 at 1050 ** about the steel type of No.5 of this invention, No.7, and No.17 to Table 4. An average crystal grain diameter, proof stress, and elongation when time vacuum annealing was carried out were summarized. The average crystal grain diameter was measured [nm / not less than 100] using the electron microscope using the X-ray diffraction method about 100 nm or less. It is a temperature higher than Examples 1 and 2 to the mechanical-alloying-treatment powder of the presentation shown in Table 1, and is HIP treatment. [2:900 ** of condition x 0.5 hour, 2000 kgf/cm^2, 3:950 ** of condition x 0.5 hour, 2000 kgf/cm^2] It carried out. On the conditions 2, the average crystal grain diameter became large rather than Examples 1 and 2, and the average crystal grain diameter of submicron size was obtained on the conditions 3. The crystal grain diameter obtained on each condition about the steel type of No.5 of this invention as a typical example in Table 5 was summarized.

[0051]

[Table 3]

表 3

	平均結晶粒径(nm)	0.2%耐力(MPa)	伸び(%)
No.5－1	20	735	0.9
No.5－2	50	775	1.2
No.5－3	80	790	3.2
No.5－4	200	690	3.6
No.5－5	275	529	13
No.5－6	350	486	21
No.5－7	370	607	5.0
No.5－8	425	464	18
No.5－9	486	454	17
No.5－10	500	486	13
No.5－11	796	457	25
No.5－12	816	415	18
No.5－13	1095	401	23
No.5－14	1800	363	24
従来材	20000	200	57－65

[0052]

[Table 4]

表 4

No.	平均結晶粒径(nm)	0.2%耐力(MPa)	伸び(%)
5	486	454	17
7	421	472	14
17	413	475	13

[0053]

[Table 5]

表 5

	温度(℃)×時間(h)	圧力(kgf/cm²)	平均結晶粒径(nm)
条件1	850(℃)×0.5(h)	2000(kgf/cm²)	20
条件2	900(℃)×0.5(h)	2000(kgf/cm²)	65
条件3	950(℃)×0.5(h)	2000(kgf/cm²)	250

[0054]Drawing 10 is the diagram which made the average crystal grain diameter (d) the natural logarithm graduation and in which showing a relation with proof stress (y) 0.2%. Since the relation with the intensity in the small portion was not clear when the crystal grain carried out minuteness making more in drawing 9, it expressed like drawing 10. Although it is so clear that intensity becomes high that a crystal grain is small as shown in a figure, it turns out that some relations are accompanied and the relation between intensity and particle diameter is shown. It seems that it is closely related to them since particle diameter is adjusted with the relation between heat treatment temperature and cooking time. The formula shown in a figure expresses a straight line. Sintered steel of austenitic steel containing 0.02% C-2.1%Mo in this example is obtained between y=-177logd+936 of a lower limit, and y=-240logd+1233 of upper limit. Mo is contained and upper limit turns around the lower limit of what is not on about 100 MPa(s) with the mean particle diameter of 400 nm by containing the circumference of the bottom of about 50 MPa(s) and also Ti, Zr, and Nb with the mean particle diameter of 400 nm.
[0055]Drawing 11 is the diagram which made pace-of-expansion (%) delta the natural logarithm graduation and in which showing a relation with proof stress (y) 0.2%. As shown in a figure, proof stress is expressed by a relation with a pace of expansion by some straight lines like drawing 10 0.2%. In sintered steel in this example, the thing between y=-290logdelta+720 of a lower limit and y=-670logdelta+1375 of upper limit is obtained. In 20%, a top turns [with alloy composition / circumference of lower] about 50 MPa(s) around 100MPa in upper limit in a lower limit by a pace of expansion like the above-mentioned.
[0056]It hot-rolled and quenched to the bulk material solidified in this example and Examples 1 and 2 to the rolling reduction of 5% - 40% in the temperature requirement (700 ** - 1050 **), and the tensile test (rate of strain: -10^{-4}/s) was done to it at the room temperature after that. Proof stress and elongation improved rather than the material which carried out vacuum annealing after solidification shaping by HIP treatment. The stress-strain curve of the sample hot-rolled to the rolling reduction of 20% at 700 ** was shown in drawing 12 about the steel type of No.5 of this invention as a typical example, and the average crystal grain diameter obtained when it hot-rolled at 700 ** to Table 6 was shown.
[0057]
[Table 6]
表 6

圧下率(%)	平均結晶粒径(nm)
20	40
40	38
60	40
40	32

[0058]The CBB examination was done on the bulk material in which crystal grain super-minuteness making austenitic steel of the presentation shown in the example 4 table 1 carried out HIP treatment as testing of stress corrosion cracking. Drawing 13 is a perspective view showing a CBB test method. It inserted between the electrode holders 19 with the graphite fiber wool yarn 18 for giving a crevice to the specimen 17, the bolt was inserted in the bolthole 20, th R was attached and bound tight between the electrode holders 19, and testing of stress corrosion cracking was presented in autoclave. The test condition was immersed for 500 hours in the high-temperature-high-pressure pure water (dissolved oxygen amount of 8 ppm) of 288 * and 85 kg/cm². The specimen was taken out after that and the existence of the crack

generation was investigated from section observation of the specimen by an optical microscope. The crack was accepted in no samples.

[0059]Hot forging of the crystal grain super-minuteness making austenitic steel of No.5 of this invention produced in example 5 Example 1 was carried out at 800 **, and the board (a stick 20 mm in diameter and 300 mm in length and 50 mm in width, 200 mm in length, and 5 mm in thickness) was manufactured as a general industrial use structural member. Hot forging of the crystal grain super-minuteness making austenitic steel of No.2 of this invention produced in Example 1, No.5, and No.17 was carried out at 800 **, and the various structural members for boiling water reactor cores shown in drawing 14 were manufactured. It is operated by the steam temperature of 286 **, and steam pressure 70.7atg, and 500 and 800 or 1100 MW power generation are possible for this nuclear reactor as a generation output. Each name is as follows. The neutron source pipe 51, the core support plate 52, the neutron instrumentation detection tube 53, the control rod 54, the reactor core shroud 55, the top guide 56, the fuel assembly 57, the upper mirror spray nozzle 58, the vent nozzle 59, the pressure vessel lid 60, the flange 61, the nozzle 62 for measurement, the steam separator 63, The shroud head 64, the water supply inlet nozzle 65, the jet pump 66, the steam drying machine 68, the vapor outlet nozzle 69, the feed water sparger 70, the nozzle 71 for core sprays, the lower reactor core lattice 72, the recirculated water entrance nozzle 73, the baffle plate 74, the control rod guide tube 75.

[0060]The above-mentioned top guide 56 has the rim trunk 21, the flange 22, and the shot plate 35, and the rolled stock of SUS316 steel polycrystal is used for these. Immobilization is not carried out mutually only by the shot plate 35 crossing mutually. Similarly SUS316 steel polycrystal rolled stock is used, it is manufactured by the rolled plate of one sheet, the hole to which fuel dummy support is attached is provided, and the core support plate 52 is fixed to a furnace container in a circumference surface. Therefore, all are structures without a soldering part in the central part which receives neutron irradiation.

[0061]Drawing 15 is a partial top view of a top guide. Drawing 16 is the sectional view where the sectional view and drawing 17 of drawing 15 VII-VII cutting expanded the drawing 18 XIII portion The alloy of above-mentioned this invention is applied to the bolt 23 of drawing 17. The bolt 23 of this invention fixes the rim trunk 21 and the upper flange 22, and manufactures a screw by cutting from the material of a round bar.

[0062]As for the elements on larger scale of a top guide, and drawing 19, elements on larger scale and drawing 20 of drawing 18 of drawing 18 X are the elements on larger scale of drawing 19 IX. The bolt 36 and the nut 37 in which the bolt and the nut, the shot plate 31, the support plate 32 and the support plate 32 which bind tight the shot plate 31 and the support plate 32 of the top guide 56, and are fixed, and the shot plate 35 are fastened. It produced like **** with No.2 of this invention, No.5, and No.17 super-fine crystal grain austenitic steel.

[0063]Drawing 21 is a sectional view of the core support plate 52, and they are the fuel dummy support of drawing 22, the circumference fuel dummy support of drawing 23, and the drawing 21 XV enlarged drawing of drawing 24 at a core support plate. The eyebolt 42 is formed and the article of these drawing 22 - drawing 24 is produced with super-fine crystal grain austenitic ste of above-mentioned this invention. The core support plate pin and the washer 43 of drawing 25 which are attached to the core support plate 41 were similarly produced with super-fine crysta grain austenitic steel.

[0064]Furthermore, drawing 25 shows the repair method which consists of the clamp 77, the bo 78 for repair, and the nut 79 for repair which protect mechanically a portion including faults, su as stress corrosion cracking generated in the boiling water reactor core various structures 55, for example, a reactor core shroud. A repairing part sectional view when drawing 26 uses the taper-less bolt 80, and drawing 27 are the repairing part sectional views at the time of using th bolt 81 with a taper, and the bolt 81 with a taper fixes the reactor core shroud 55 and the clam 77 via the sleeve 82 with a slit. The above-mentioned bolt and the nut were produced with super-fine crystal grain austenitic steel of No.2 of this invention produced in Example 1, No.5, and No.17.

[0065]The conditions which produce the member produced by the method of aforementioned this invention all over a boiling-water reactor were imitated, and neutron irradiation was furthe

arried out to 1x10 ^{22}n/cm^2 (>1MeV) in the amount of neutron irradiation. The tensile test (rate f strain: -10^{-4}/s) was done to non-glaring material and exposure material at the room emperature. Crystal grain super-minuteness making austenitic steel by this invention had slight xposure degradation of the material conventionally represented by the increase in proof stress nd the fall of elongation as compared with practical use material 316L steel. Ti, Zr, and the naterial that carried out Nb addition showed good radiation damage-proof nature also in this nvention material. The proof stress and elongation before and behind an exposure were ummarized in Table 7 about practical use material 316L steel No.2 in Table 1 of this invention, Jo.5 and No.17, and conventionally as a typical example.
0066]
Table 7]

表 7

上段：非照射材
下段：照射材

No. (粒径：d)	耐力(MPa)	伸び(%)
2	762	15
(d=82nm)	785	13
5	780	12
(d=70nm)	801	10
17	761	17
(d=85nm)	770	16
316L鋼	210	60
(d=20μm)	1100	0.4

[0067]The amount of neutron irradiation is a portion which receives the high neutron irradiation which is 1x10 ^{22}n/cm^2 as a use part mentioned above, and it is important like a bolt and a nut to receive high stress and to constitute the member which cannot carry out direct observation of the surface from the exterior by the high member of radiation damage-proof nature. And these members need to consider it as construction material with the surrounding structure, resemblance, or the almost same presentation also from the point which makes equivalent potential in the inside of elevated-temperature pure water. Since it can work as a disappearance place of an exposure defect, accumulation of the defect by the exposure in a host phase is suppressed more, and depressor effect of a lot of grain boundaries included in the super-fine crystal grain austenitic steel produced by the method of this invention, such as what is called irradiation embrittlement and bottom creep of an exposure, is also large.
[0068]Although the bolt and the nut were manufactured in this example, it is also dramatically effective to use the shot plate 35 of a top guide and the core support plate 52 with super-fine crystal grain austenitic steel of the same material. And since a large-sized member can be manufactured with the hydrostatic pressure between heat, according to the kind of member, a presentation can be chosen and drawing 15 - all the various structural materials in a furnace of drawing 27 can be used.
[0069]The sectional view and drawing 29 of a cutting plane of the top guide 56 with circular drawing 28 are a sectional view of the cutting plane of the circular core support plate 52. These structures are manufactured by welding using the board obtained using the alloy of No.5 similarly shown in Table 1 by hot-rolling and heat treatment by the manufacturing method shown in Example 1.
[0070]Drawing 30 is a reactor core region section enlarged drawing showing the neutron instrumentation detection tube 53. The neutron instrumentation detection tube 53 is connected to the housing by which welded connection was carried out to the reactor pressure vessel lower mirror by welding. In this example, using the alloy of No.5 similarly shown in Table 1, the

seamless neutron instrumentation detection tube 53 is manufactured by between heat, and final heat treatment of a statement is performed to Example 1.

[0071]Drawing 31 is a perspective view of a control rod, and they are a sheath and B_4C at this example. The alloy of No.5 shown in Table 1 was used for the tube. B_4C The tube repeated and obtained cold rolling and annealing by the Pilger mill, after making the element tube by between heat. After the sheath repeated cold rolling and annealing and used them as sheet metal, it was obtained by welding.

[0072]Drawing 32 is a fragmentary sectional view of the fuel assembly 57. The main composition of the fuel assembly 57 consists of the fuel rod 151, the water rod 152, the channel box 154, the top stay plate 155, the bottom tie plate 156, the spacer 157, and the handle 161, and many bolts and nuts for joining together are used. The alloy of this invention can be used for these component parts. Solution treatment of the sheet metal of a channel box and a spacer is carried out after hot-rolling, it repeats cold rolling and annealing, and is manufactured [solution treatment is performed after hot forging to the structural material of a handle, the upper part, and a bottom tie plate,], and the covering pipe of a fuel rod and the thin wall tube of a water rod are manufactured by the Pilger mill.

[0073]Drawing 33 is a fragmentary sectional view of a fuel rod, and the alloy which the covering pipe 164 and the end plug 167 require for this invention is used.

[0074]Drawing 34 is a partial section perspective view of a neutron source pipe, and it manufactured using the alloy of No.5 shown in Table 1 in this example. The pipe portion of this pipe was used as the seamless pipe between heat, and the portion of an upside stick and the lower heavy-gage portion were obtained according to the manufacturing process same also with hot forging and heat treatment as Example 1. Each joined part was joined by electron beam welding.

[0075]The main specifications of the BWR power generating plant obtained by the above composition are as being shown in Table 8. According to this example, each of each members constituted with the alloy concerning this invention became usable by no exchanging for 30 years, and also the prospect which can be used by no exchanging by inspection in 40 years was acquired. It is 288 **, nuclear reactor temperature is after 12-month operation, and not less than 85% of an operating ratio will make it into 35% of thermal efficiency 92% especially not less than 90% the 40th [less than] day preferably the 50th [less than] day per time while the periodic check in 30 days is carried out especially repeatedly preferably.

[0076]Example 6 drawing 35 is a sectional view of the nuclear reactor in new style boiling water type nuclear power generation.

[0077]A reactor pressure vessel is central apparatus of a nuclear power plant.
Especially in ABWR, the nozzle part which attaches an internal pump is the sleeve type optimal shape which does not affect it to the rotary function of an internal pump and whose transfer of the heat to an electric motor part decreases, even if temperature and pressure variation arise i a reactor pressure vessel.

[0078]The structure in a furnace lessens influence on the fluid vibration by internal pump adoption.

[0079]The reservation of accuracy also including a verification according [measurement of a core flow] to an experiment in consideration of the state of partial operation of an internal pun is achieved. The venturi structure provided in the main steam nozzle part of the reactor pressure vessel performs measurement of the vapor flow rate which flows into a turbine, and measurement accuracy is secured enough.

[0080]RPV (reactor pressure vessel) has the function to build in and hold a reactor core and a pressure vessel internal while constituting the pressure boundary of a coolant.

[0081]Although 764 fuel assemblies, the jet pump, and the internal were stored and it was set t about 6.4 m in inside diameter in the conventional RPV, in ABWR, the fuel assembly's having increased to 872 bodies and the handling space in a furnace of the internal pump were secured and the inside diameter was about 7.1 m.

[0082]The inner quantity of the conventional RPV was about 21 m by the factor of (a) - (d) shown below by ABWR to being about 22 m.
[0083](a) Stand pipe length was shortened by adoption of the efficient steam separator.
(b) By adoption of FMCRD, the control rod falling speed limiter became unnecessary.
[0084](c) The upper pig height by the upper pig and a main flange structural change was made low.
[0085](d) The height of the pan mold configuration of a lower mirror was made low.
[0086]Lower mirror shape used lower mirror shape as the pan type from the conventional hemisphere type in consideration of securing the installation space requirement to the pressure vessel lower part of an internal pump with adoption of an internal pump, and the circulation flow passage of cooling water. The internal pump was really considered as the forge and it was considered as little design of the number of weld lines.
[0087]In order to install the heat exchanger for internal pumps in a pedestal, the support skirt was made into conical shape at the drum section, while it secured the space required for the handling of an internal pump, etc.
[0088]Since the coolant recycle exit and entrance nozzle of the conventional plant are lost with adoption of an internal pump, it is not necessary to make it what does not have a large caliber nozzle below in a drum section core region, and to assume a big coolant loss accident.
[0089]Although the flow limiter was installed in the falling portion which results in the separation valve on a main steam pipe in the conventional plant, the improvement of a margin of safety to a main steam pipe rupture accident and optimization of the container space were attained by installing this in a main steam nozzle.
[0090]Comparison with BWR of Example 5 of the structure principal items in a furnace is shown in Table 8.
[0091]The structure in a furnace is in RPV and sufficient soundness and reliability are demandec on [, such as reservation etc. of the reactor core irrigation way of the cooling water under a hypothetical accident besides duties with a main function etc. which carry out steam separation of the support in a furnace, formation of the channel of a coolant and the hot water by which it was generated in the reactor core, and the steam,] the character.
[0092]
[Table 8]

表 8

項目	ABWR	BWR
電気出力	1350MW	1100MW
原子炉熱出力	3926MW	3293MW
原子炉圧力	7.17MPa(73.1kgf／cm^2)(abs)	7.03MPa(71.7kgf／cm^2)(abs)
主蒸気流量	7480t／h	6410t／h
給水温度	215℃	215℃
定格炉心流量	52×10^6kg／h	48×10^6kg／h
燃料集合体数	872体	764体
制御棒本数	205本	185本
炉心平均出力密度	50.5kW／l	50.0kW／l
原子炉圧力容器 内径	7.1m	6.4m
原子炉圧力容器 高さ	21.0m	22.2m
原子炉再循環方式 (ポンプ台数)	インターナルポンプ(10)	外部再循環ポンプ(２) ジェットポンプ(20)
制御棒駆動方式 通常	微調整電動式	水圧駆動式
制御棒駆動方式 スクラム	水圧駆動式	水圧駆動式
非常用炉心冷却系	自動減圧系 高圧系(３系統) 低圧系(３系統)	自動減圧系 高圧系(１系統) 低圧系(４系統)
原子炉停止時冷却系	３系統	２系統
原子炉格納容器形式	鉄筋コンクリート製 ライナ内張り	鋼製自立式
タービン形式	TC6F－52型(２段再熱)	TC6F－41／43型(非再熱)
気水分離器	二重管，３段式×349本	三重管，２段式×225本
給水スパージャサーマルスリーブ	溶接型二重サーマルスリーブ	溶接型一重サーマルスリーブ
高圧炉心注水スパージャ	注水方式	スプレー方式
低圧注水スパージャ	ダウンカマ注入方式	シュラウド内注入方式
上部格子板	一体削り出し型	格子板はめこみ型
炉心支持板	クロス補強ビーム	平行補強ビーム
インコアスタビライザ	２段，シュラウド固定	１段，シュラウド固定なし
制御棒	速度リミッタなし バイオネットカップリング方式	速度リミッタあり スパッドカップリング方式
シュラウドサポートレグ	高さ：21.7インチ 10本(インターナルポンプ間に配置)	高さ：57.5インチ 12本
最大被中性子照射量	$4\sim5\times10^{22}$n／cm^2	1×10^{22}n／cm^2
運転年数	30年以上	30年以上
平均出力 (稼動率)	85%以上	85%以上
運転期間	12ケ月／回	12ケ月／回
定検期間	50日以内／回	50日以内／回

[0093]When Table 9 compares the basic specification of the steam turbine and generator equipment for ABWR plants by the object for 50 Hz, it is the efficient form plant considered as the increase of electric-generating-power 23.3% to the increase of reactor-thermal-power 19.2 in an ABWR plant as compared with a BWR plant.
[0094]Although the sintered steel which has a bolt for combination of each furnace inner material and 10-600 nm of average crystal grains given [a nut] in Examples 1-4 like Example ! also in this example can be used of course. In addition, it is the same as that of the above-mentioned example also about application to the structure in a furnace given in Example 5.
[0095]
[Table 9]

表 6

項	目	ABWRプラント	BWRプラント	
			A	B
1. 原子炉	●定格熱出力	3926MW	3293MW	3293MW
	●給水温度	215℃	215.5℃	215.6℃
2. タービン	●型式	TC6F−52	TC6F−41	TC6F−43
	●定格電気出力	1356MW	1100MW	1137MW
	●主蒸気圧力	6.79MPa(abs)	6.65MPa(abs)	6.65MPa(abs)
	●回転数	1500r／min	1500r／min	1800r／min
3. 復水器	●定格真空度	5.07kPa(abs)	5.07kPa(abs)	5.07kPa(abs)
	●冷却管材料	チタン	チタン	チタン
	●内蔵ヒータ	低圧４本	低圧４本	低圧４本
4. 湿分分離加熱器	●型式	２段再熱式	非再熱式	２段再熱式
5. 主蒸気系	●主蒸気管導入	サイドエントリー	フロントエントリー	フロントエントリー
6. 復水給水	●給水ポンプ	TDRFP×２台 MDRFP×１台	TDRFP×２台 MDRFP×２台	TDRFP×２台 MDRFP×２台
	●ヒータドレン	ポンプアップ	カスケード	カスケード
7. 発電機	●型式	TFLQQ-KD	TFLQQ-KD	TFLQQ-KD
	●定格出力	1540MVA	1300MVA	1280MVA
	●極数	4	4	4
	●力率	0.9	0.9	0.9

ABWR(改良型沸騰水型原子炉), BWR(沸騰水型原子炉), TDRFP(タービン駆動給水ポンプ), MDRFP(電動機駆動給水ポンプ)

[0096]Example 7 drawing 36 is a perspective view of the structure in a furnace of a pressurized water reactor (PWR).

[0097]There are a nuclear reactor, a primary-cooling-of-concrete circuit, its auxiliaries, etc. in nuclear reactor relation equipment, and as shown in a figure, it consists of a reactor vessel, the furnace stored in it, the structure in a furnace, a control rod cluster, and a drive.

[0098]In a top, a fuel assembly group is the portion fixed with the lower core plate and the baffle (shroud), and, on the whole, the reactor core is making the cylindrical shape mostly.

[0099]The coolant entrance nozzles and the low-pressure injection nozzle of a reactor vessel are further attached up from the reactor core upper part, and it is considered that a reactor core is always in a coolant.

[0100]The primary coolant containing the nozzle of the reactor vessel upper part flows through the ring part between a core barrel structure and a reactor vessel caudad, changes a direction up at the reactor vessel pars basilaris ossis occipitalis, passes along a mixing plate, and goes int the core lower part by first-class quantity distribution. The primary coolant which absorbed the heat generated by the nuclear fission of a fuel element, and became an elevated temperature is sent to a steam generator from the nozzle of the reactor vessel upper part.

[0101]The reactivity which a reactor core has is controlled by the two following methods.

[0102](i) Control of the comparatively rapid reactivity change accompanying starting by a contr rod cluster, a stop, a change of load, etc.

[0103](ii) Control of slow reactivity change, such as change of reactivity which takes place by change of the reactivity accompanying change of compensation of the reactivity reduction accompanying the fuel combustion by adjustment of the boron concentration dissolved into a primary coolant, Xe, and Sm, and the temperature change from ordinary temperature to an operating temperature.

[0104]In the top, the reactor core is mostly formed in the cylindrical shape by the output with the lower core plate and the baffle in the fuel assembly of the predetermined number. A generation output and the number of fuel assemblies are [in 121 pieces and 800MWe] 193-24 pieces in 300 - 550MWe at 157-177 pieces and 1100MWe.

[0105]Reactor core weight is supported by the flange of the reactor vessel with a lower core support plate, a core barrel, an upper furnace heart support plate, etc. The lateral vibration of a reactor core region is controlled by the reactor vessel side key groove in the position corresponding to some keys and it in the core barrel lower end side.

[0106]A reactor core is divided into three fields which have a fuel assembly of the concentric circle shape of the same number generally, in the case of initial loading fuel, enrichment is changed, and it loads the high fuel assembly of enrichment in the direction of a peripheral part. Although it is 3 which the fuel of a central region is taken out in the case of a fuel exchange, move the fuel of two fields of the outside to a central direction, and load a periphery with new

fuel fields, and a formula 3 cycle method in outside ->, The fuel which reached the degree of high combustion of the others and reactor core center section is taken out, the system of the fuel of a peripheral part is carried out to the position, and new fuel is loaded in a peripheral part. There is also what is called a 3 field checkerboard type 3 cycle method.
[0107]By these methods, flattening of the output distribution of a reactor core can be carried out, and power density can be made high, and the average burnup of fuel can become high, and a fuel cost can be reduced. In PWR, although a fuel replacement period changes with fuel, it is one years or more.
[0108]A burnup goes up gradually and there is a thing of equilibrium core average about 33000 MWD/MT (maximum combustion degree 50000 MWD/MT).
[0109]The sintered steel which has a fine crystal grain with an average crystal grain diameter of 10-600 nm of a statement in the Examples 1-5 as a structural material in a furnace like Example 6 also in this example can be used. As parts of the structural material in a furnace, in an upper furnace heart support plate, a core barrel, an upper core plate, and a fuel assembly, like Example 5, Especially the bolt and nuts that combine these besides a lower core support plate, a lower core plate, a baffle support plate, a core baffle, a control rod cluster, support putt, a control rod cluster guide pipe, and a control rod cluster driving shaft are effective. According to this example, the same operation years as Example 5, an operating ratio, an operating period, constant ******, and thermal efficiency are acquired.
[0110]Example 8 drawing 37 shows the outline of the Taurus type fusion device in which this invention steel was used, with drawing of longitudinal section. In a figure, inside the poloidal magnetic field coil 134 which performs heating and control of the plasma 133 on the pace 131, the diverter coil 135, and the toroidal magnetic field coil 136 which shuts up the plasma 133, in the vacuum housing 137 of a hollow doughnut shape, For example, while putting in heavy hydrogen or tritium as fuel inside the blanket 138 which supplies and carries out heat exchange of a cooling agent like helium and generating the plasma 133, Fit in the lower part 137a of the above-mentioned vacuum housing 137 at the shield cylinder object 139, and it is connected to the above-mentioned diverter coil 135 inside this shield cylinder object 139, A part of plasma 133a (impurities, such as helium) pulled out from the plasma 133 by each diverter 141 supported by the condenser tube header 140 is applied, Furthermore, the exhaust air pump 143 is formed ir the opening 139a of the above-mentioned shield cylinder object 139 via the exhaust pipe 42, anc the neutral beam injector 144 is installed in the above-mentioned vacuum housing 137 of the higher rank of the above-mentioned exhaust pipe 142.
[0111]The fusion device puts in heavy hydrogen etc. in the vacuum housing 137 which has watei cooled structure, On the other hand, supply current to the above-mentioned poloidal magnetic field coil 134, the diverter coil 135, and the toroidal magnetic field coil 136, and replace heavy hydrogen in the above-mentioned vacuum housing 137, etc. by the plasma 133, and, In the vacuum housing 137, illuminate a neutral particle with the neutral beam injector 144, and the plasma 133 is heated secondarily, Heat exchange of the thermal energy produced to this plasma 133 is carried out to the cooling agent which flows into the blanket 38, this cooling agent that carried out heat exchange is taken out out of a device, and, thereby, a turbine may be driven, foi example. The impurity produced by sputtering of the plasma 133 in the vacuum housing 137 on the other hand, It not only reduces plasma generation efficiency, but since it becomes a cause c damage by the high temperature of the vacuum housing 137 surface, the diverter 141 is formed in order to remove the impurity leading to this damage.
An impurity is applied and removed to the diverter 141.
The first wall 146 was established inside the blanket 138, and the ceramic style 148 had carried out metal junction in the metal base 147 by which water cooling is carried out.
[0112]Drawing 38 shows the outline of the diverter 141. In a figure, the diverter 141 serves as big heat load and electromagnetic force with a big eddy current generated in the diverter 141 from plasma, and acts. A long board is located in a line with two or more torus directions, and the diverter 141 is supported by the supporting frame 145 attached to the undersurface of the condenser tube header 140, the subheader 140a, and the diverter 141. The diverter 141 makes two or more sheets 1 block, and is constituted by the torus direction with two or more blocks.

Each block has the structure which the ceramic style 148 combined with the metal base 147 by which water cooling is carried out. What has the high heat conductivity more than 0.2 cal/cm-sec and ** is preferred, and the ceramic styles 148 are Be or Be compound especially to SiC 0.2-2 It is preferred to use the sintered compact included in the sintered compact, AlN, or this which is included as for more than weight % like the above-mentioned Be compound.
[0113]In this example, it has structure which the diverter 141, the vacuum housing 137, and the first wall 146 receive the exposure of various corpuscular beams which each reveals from a lot of neutrons and plasma, and touches water for cooling, and high temperature hot water will be contacted. By producing with steel in connection with No.5 of Table 1 to the metal base of these structures, the grain boundary hydrogen crack sensitivity under neutron irradiation can be reduced, and improvement in irradiation embrittlement-proof nature can be measured.
[0114]After hot-rolling and each of these structures repeats [which is shown in Example 1] cold rolling and annealing, they performs 1050 ** and solution treatment for 30 minutes to the **, and consists of all the austenite phases.
[0115]
[Effect of the Invention]According to this invention, since a grain boundary is generally applied to the reinforcement member used by environment-ization which can serve as the main factor of material degradation and it excels in corrosion resistance and intensity, an effect remarkable in improvement in the safety of a product and reliability is acquired. Since it is used in not only a reactor core but water cooling environment, or the environment where hydrogen exists, and is applied to the structural member for nuclear fusion reactors which receives radiation irradiation damage and it excels in radiation damage-proof nature, an effect remarkable in improvement in the safety of a product and reliability is acquired.

[Translation done.]

DESCRIPTION OF DRAWINGS

[Brief Description of the Drawings]
[Drawing 1]The figure showing the relation between the average crystal grain diameter of crysta grain super-minuteness making austenitic steel of this invention, proof stress, and elongation.
[Drawing 2]The figure showing the composition of the device used for manufacturing crystal grain super-minuteness making austenitic steel concerning this invention.
[Drawing 3]The diagram showing the milling time of the mechanical-alloying powder used for manufacturing crystal grain super-minuteness making austenitic steel of this invention, and the relation of X diffraction intensity.
[Drawing 4]The diagram showing the milling time of the mechanical-alloying powder used for manufacturing crystal grain super-minuteness making austenitic steel of this invention, and the relation of an average crystal grain diameter.
[Drawing 5]The diagram showing the relation of the phase change for which it asked from the milling time and X diffraction intensity of the mechanical-alloying powder used for manufacturin crystal grain super-minuteness making austenitic steel of this invention.

[Drawing 6]The lineblock diagram of the device used for manufacturing crystal grain super-minuteness making austenitic steel concerning this invention.
[Drawing 7]The diagram showing the heat treatment temperature of No.5 austenitic steel of this invention, and the relation of an average crystal grain diameter.
[Drawing 8]The diagram showing the heat treating time of No.5 austenitic steel of this invention, and the relation of an average crystal grain diameter.
[Drawing 9]The figure showing the average crystal grain diameter of No.5 austenitic steel of this invention, and conventional material practical use 316L steel, and the relation of proof stress.
[Drawing 10]The diagram showing the relation between proof stress and an average crystal grain diameter 0.2%.
[Drawing 11]The diagram showing the relation between proof stress and a pace of expansion 0.2%.
[Drawing 12]The diagram showing the stress-strain curve of the vacuum-annealing material of No.5 austenitic steel of this invention, and rolling quenching material.
[Drawing 13]The perspective view showing the testing-of-stress-corrosion-cracking method.
[Drawing 14]The partial section perspective view showing the reactor core using crystal grain super-minuteness making austenitic steel of this invention.
[Drawing 15]The part plan of a top guide.
[Drawing 16]The cutting plane figure of the drawing 15 VII portion.
[Drawing 17]The enlarged drawing of the drawing 15 VIII portion.
[Drawing 18]Top guide elements on larger scale.
[Drawing 19]Drawing 18 X section enlarged drawing.
[Drawing 20]Drawing 18 XI section enlarged drawing.
[Drawing 21]The sectional view of a core support plate.
[Drawing 22]The perspective view of fuel dummy support.
[Drawing 23]The sectional view of circumference fuel dummy support.
[Drawing 24]Drawing 21 XV enlarged drawing.
[Drawing 25]The figure showing the repair method of a fault part.
[Drawing 26]The repairing part sectional view which uses a taper-less bolt.
[Drawing 27]The repairing part sectional view which uses the bolt 80 with a taper.
[Drawing 28]The front view of a top guide.
[Drawing 29]The front view of a core support plate.
[Drawing 30]The sectional view of a neutron instrumentation detection tube.
[Drawing 31]The partial section perspective view of a control rod.
[Drawing 32]The sectional view of a fuel assembly.
[Drawing 33]The fragmentary sectional view of a fuel rod.
[Drawing 34]The sectional view of a neutron source electrode holder.
[Drawing 35]The sectional view of an ABWR nuclear reactor.
[Drawing 36]The sectional view showing the core internal structure of PWR.
[Drawing 37]The sectional view of a nuclear fusion reactor.
[Drawing 38]The perspective view of a diverter.
[Description of Notations]
1 [— Agitator arm,] — A pulverizing tank, 2 — The inflow of cooling water, 3 — The outflow of cooling water, 7 13 — A stainless steel container, 16 — A turntable, 23, 33, 36 — Bolt, 34, 37 [— Circumference fuel dummy support,] — A nut, 42 — An eyebolt, 43 — A washer, 44 45 — A core support plate pin, 51 — A neutron source pipe, 52 — Core support plate, 53 [— Top guide,] — A neutron instrumentation detection tube, 54 — A control rod, 55 — A reactor core shroud, 56 57 [— A steam dryer, 126 / — An internal pump, 137 / — A vacuum housing, 141 / — A diverter, 146 / — A first wall, 164 / — Fuel cladding tube,] — A fuel assembly, 63 — A steam separator, 66 — A jet pump, 68

[Translation done.]

* NOTICES *

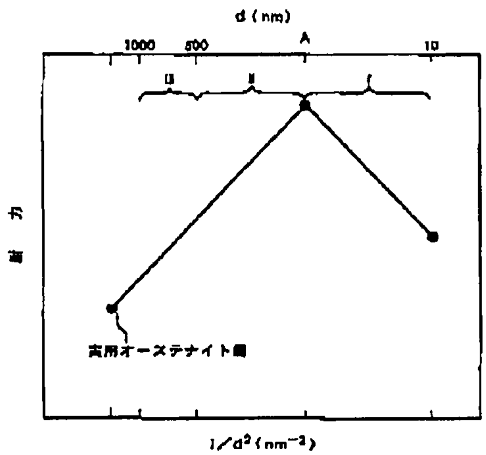
JPO and INPIT are not responsible for any
damages caused by the use of this translation.

1.This document has been translated by computer. So the translation may not reflect the original precisely.
2.**** shows the word which can not be translated.
3.In the drawings, any words are not translated.

DRAWINGS

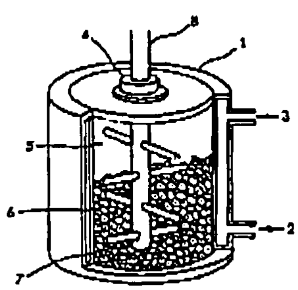
[Drawing 1]

図 1



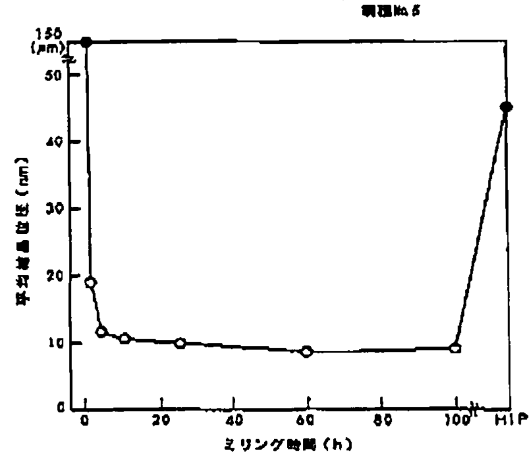
[Drawing 2]

図 2

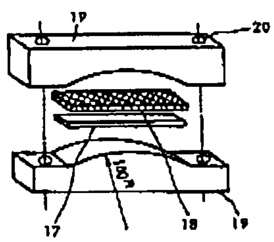


[Drawing 4]

図 4

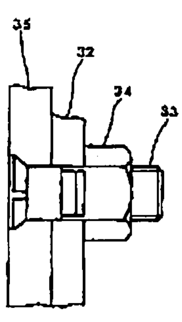


[Drawing 13]
図 13



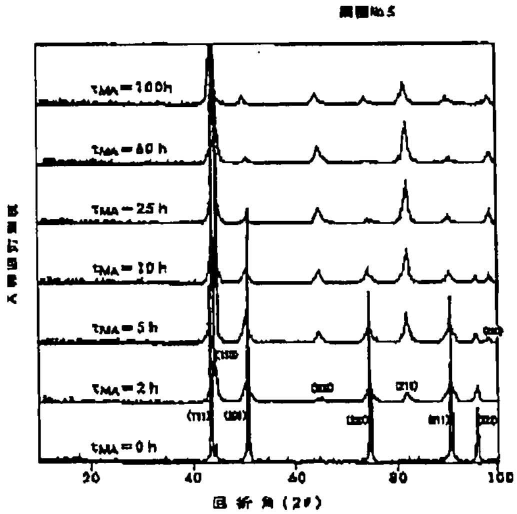
[Drawing 16]
図 16

[Drawing 19]
図 19



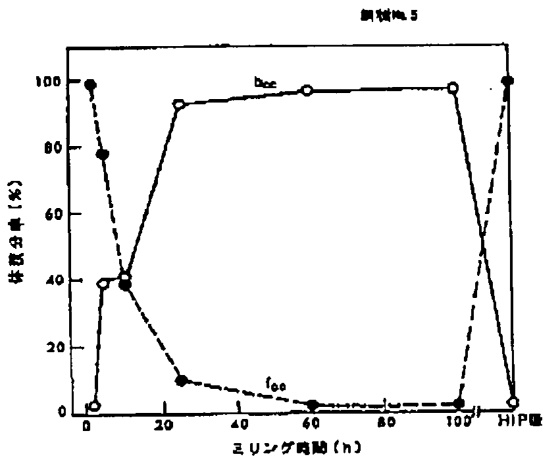
[Drawing 3]

図 3



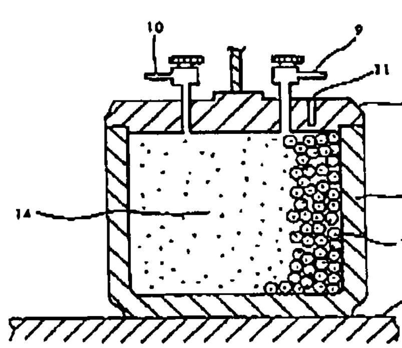
[Drawing 5]

図 5



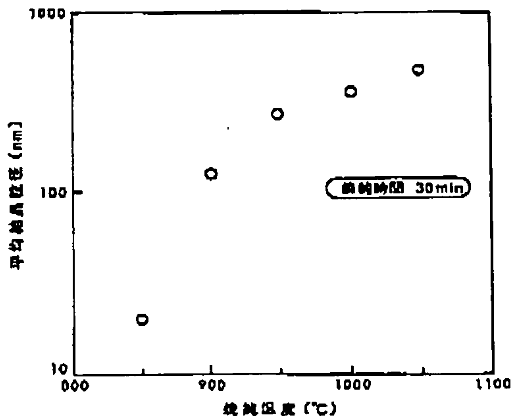
[Drawing 6]

図 6



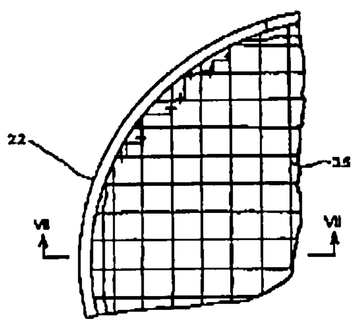
[Drawing 7]

図 7



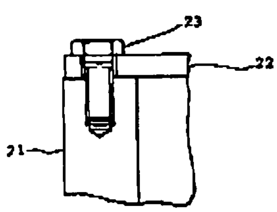
[Drawing 15]

図 15



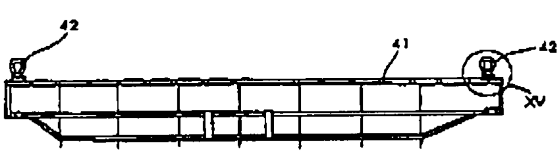
[Drawing 17]

図 17



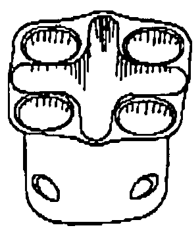
[Drawing 21]

図 21

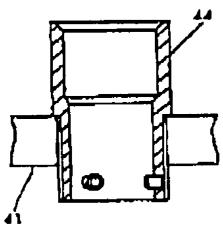


[Drawing 22]

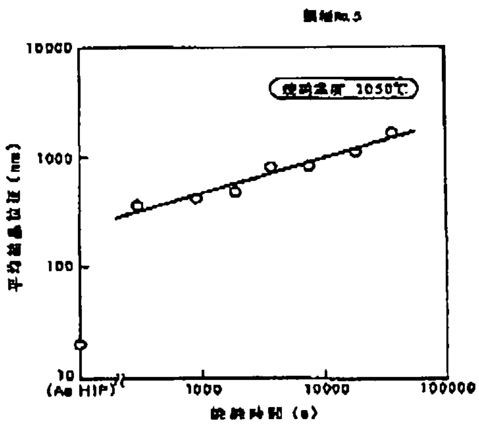
図 22



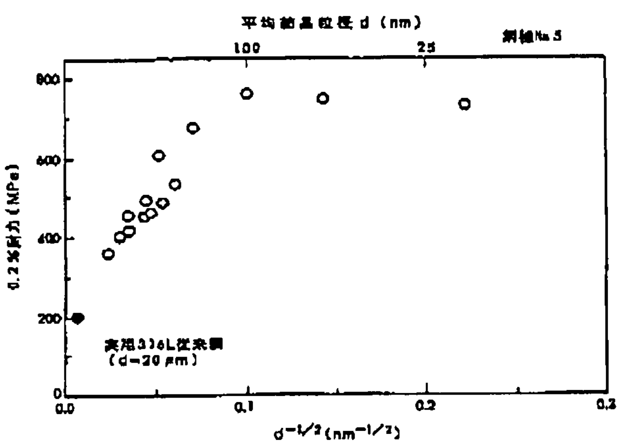
[Drawing 23]
図 23



[Drawing 8]
図 8



[Drawing 9]
図 9



[Drawing 10]

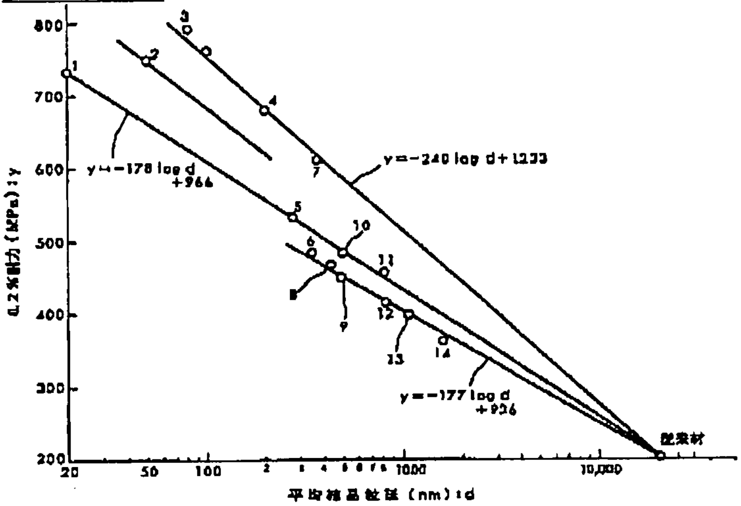
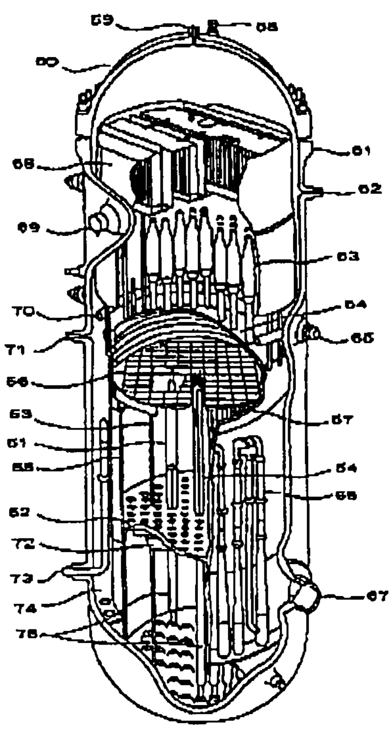


図 10

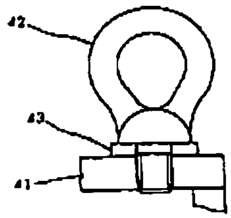
[Drawing 14]

図 14



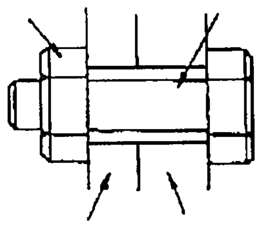
[Drawing 24]

図 24



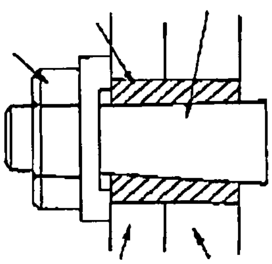
[Drawing 26]

図 26

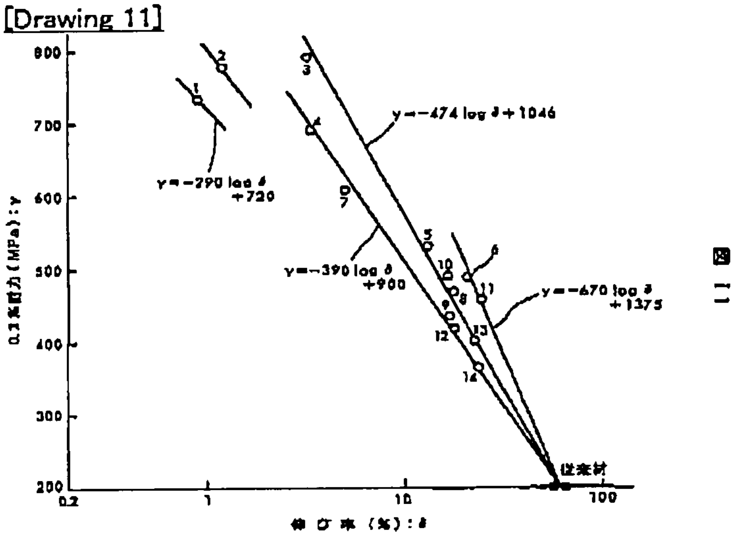


[Drawing 27]

図 27

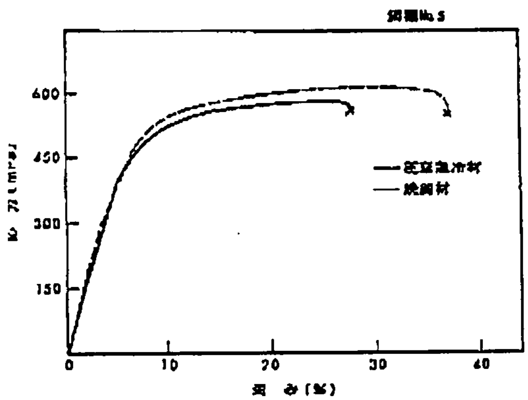


[Drawing 11]



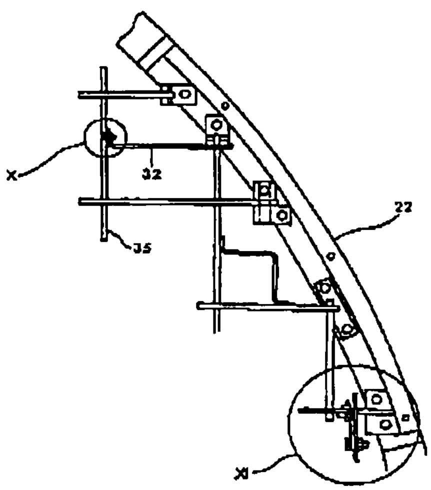
[Drawing 12]

図 12



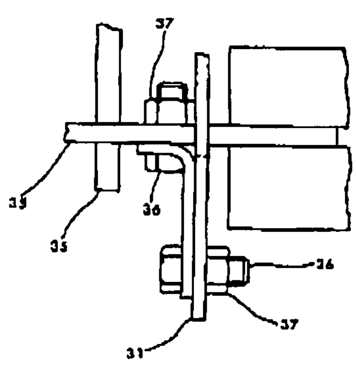
[Drawing 18]

図 18



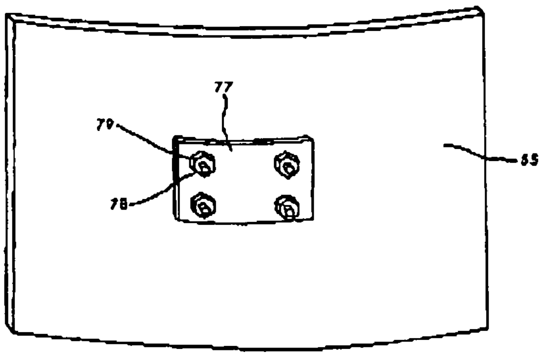
[Drawing 20]

図 20



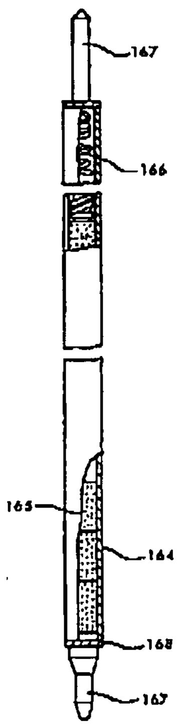
[Drawing 25]

図 25



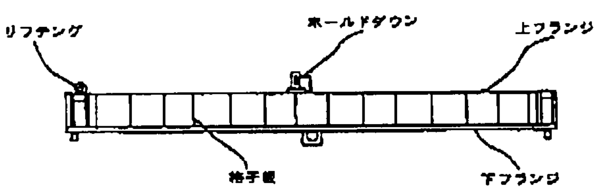
[Drawing 33]

図 33



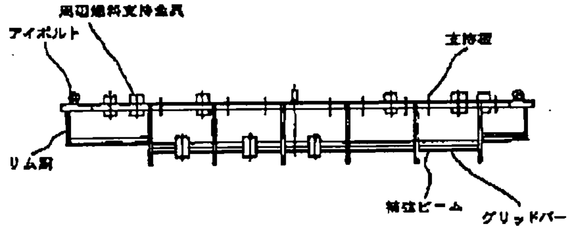
[Drawing 28]

図 28



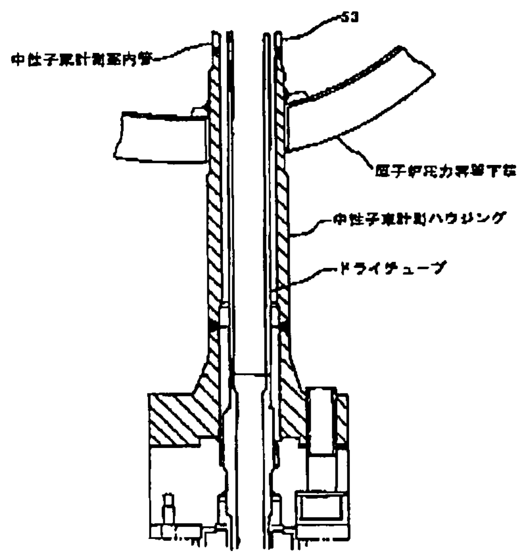
[Drawing 29]

図 29



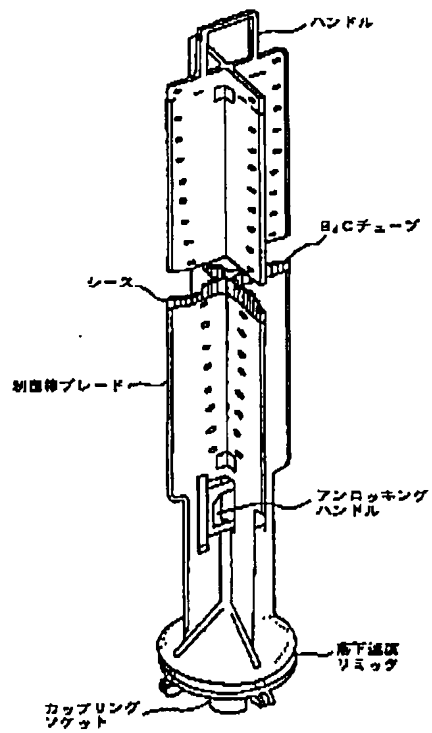
[Drawing 30]

図 30



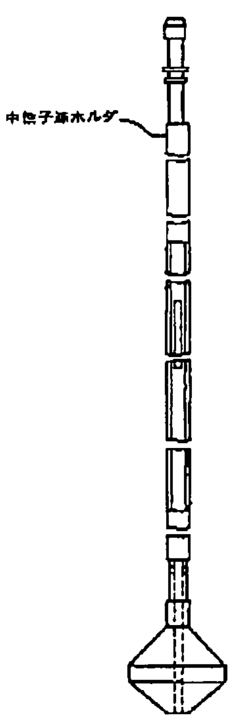
[Drawing 31]

図 31



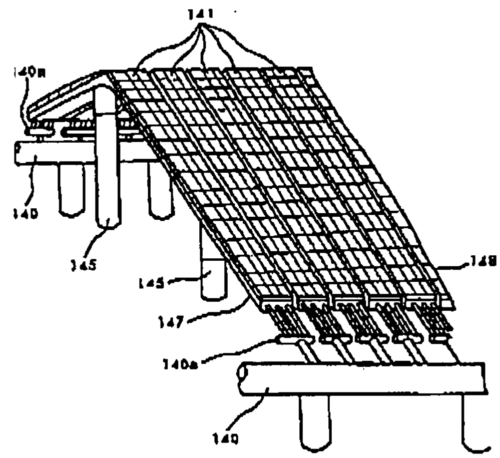
[Drawing 34]

図 34



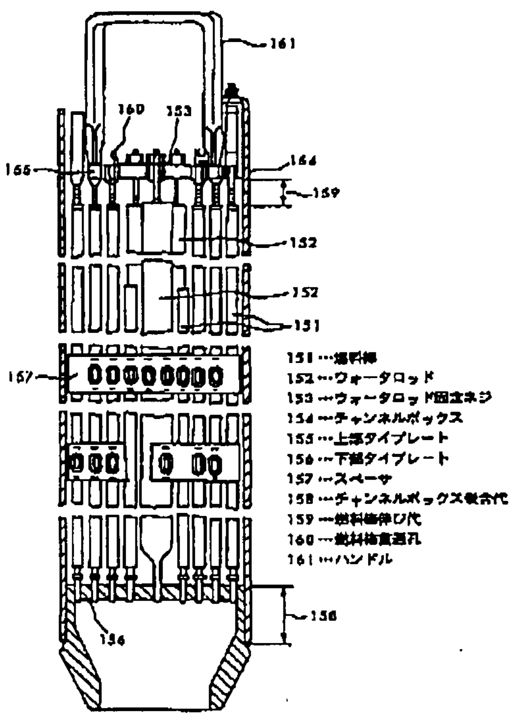
[Drawing 38]

図 38



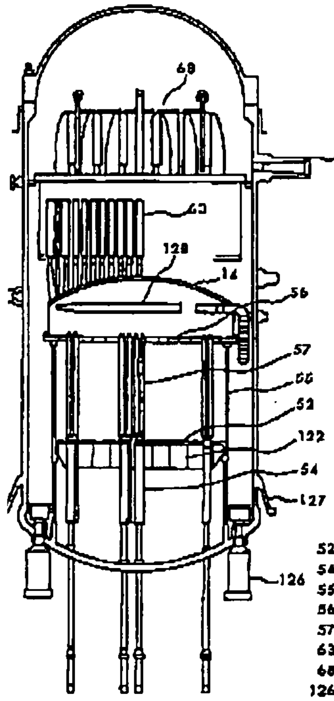
[Drawing 32]

図 32



[Drawing 35]

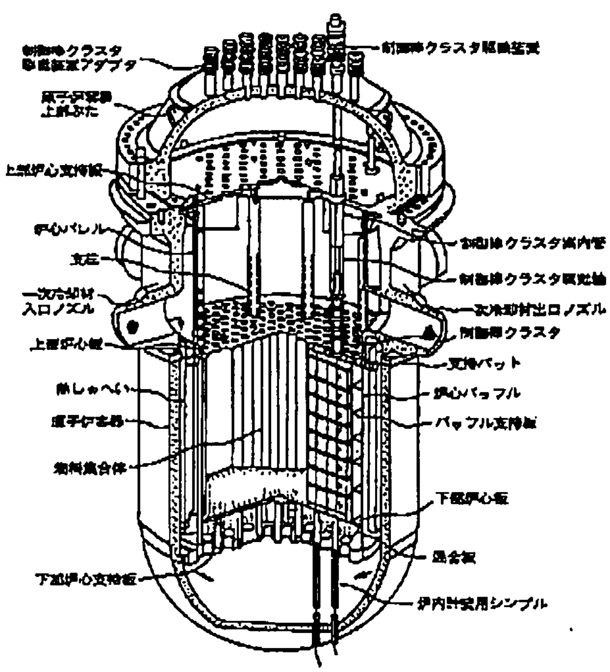
図 35



52…炉心支持板
54…制御棒
55…炉心シュラウド
56…上部格子板
57…燃料集合体
63…気水分離器
68…蒸気乾燥器
126…インターナルポンプ

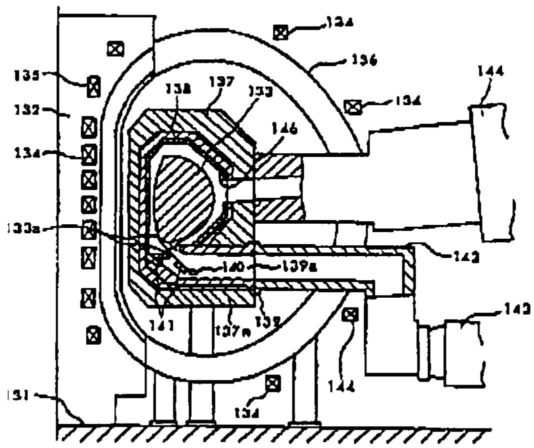
[Drawing 36]

図 36



[Drawing 37]

図 37



[Translation done.]